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Recently, 2D materials and related van der Waals heterostructures have emerged as promising platforms for enhanced light-matter interactions [1]. For instance, graphene sustains gate-tunable plasmons, hexagonal boron nitride (hBN) supports low-loss phonon-polaritons, and 2D semiconductors like transition metal dichalcogenides exhibit exciton-polaritons [1,2]. Here, we present a comprehensive theoretical account of such polaritons in a number of experimentally-relevant configurations. Both 2D material-based structures and hybrid 2D material/3D metal configurations are considered. The former concerns the study of plasmon waveguiding and hybridization in 1D-like channels made from either nanostructuring (e.g., nanoslits, nanoribbons) or bending/folding 2D materials (V-shaped wedges and grooves) [3,4]. We determine the plasmon dispersion and the modes spatial distribution using a general semi-analytical approach and verify that such platforms constitute excellent architectures for ultracompact nanophotonic devices with tunable properties [3,4]. Finally, we investigate nonlocal quantum effects in hybrid dielectric/G/hBN/metal heterostructures. These support acoustic-like graphene plasmons in the far-IR owing to the screening exerted by the nearby metal [5]. By controlling the hBN thickness, we show that the graphene plasmon's velocity can be slowed down almost up to the electronic Fermi velocity, and the plasmon dispersion approaches the electron-hole continuum [5]. We find that the interplay between huge field-confinement, nonlocal and many-body effects in graphene, and the inherently nonlocal response of the metal, all play in concert in order to render plasmons exhibiting nonlocal and quantum signatures.

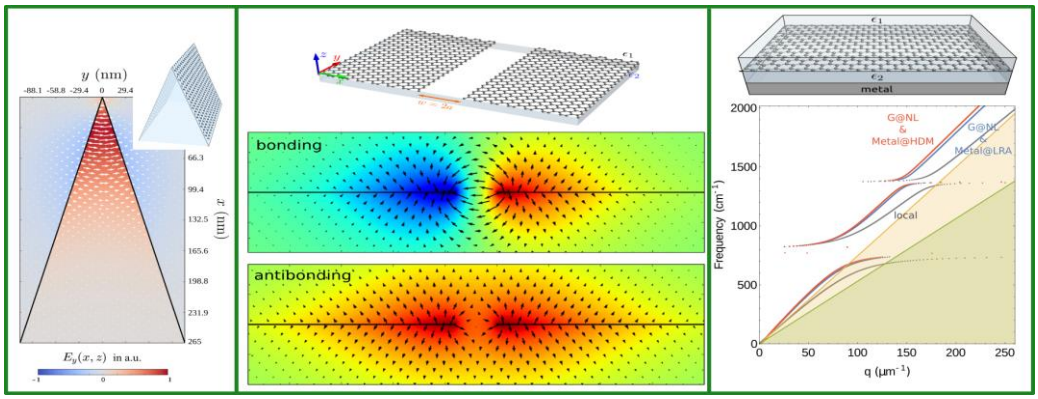

Figure 1. Plasmons in engineered graphene nanostructures. Left: Fundamental plasmon in a graphene wedge. Middle: plasmon modes in a 2D nanoslit. Right: Nonlocal and quantum effects in hybrid 2D/3D structures.

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